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(56) Documents Cited
GB 2180724 A EP 0783190 A1 EP 0762535 A1
EP 0733916 A2 EP 0058412 A2 WO 97/07414 A1
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(54) Abstract Title
Omnidirectional triple coil antenna and reciever

(57) An antenna consists of three coiled elements with mutually perpendicular axes, having either air or ferrite cores, and this antenna is connected to a receiver. The antenna and receiver system is preferably contained in a credit-card size housing or a key-fob housing where it may feature in a remote control vehicle anti-theft system. There may be additionally be a transmitter system allowing query/response dialogue between the vehicle and the remote control possibly via a inductive system. The three coils ensure reliable reception of an inductive signal from a single coil transmitter in the vehicle.

FIG 1

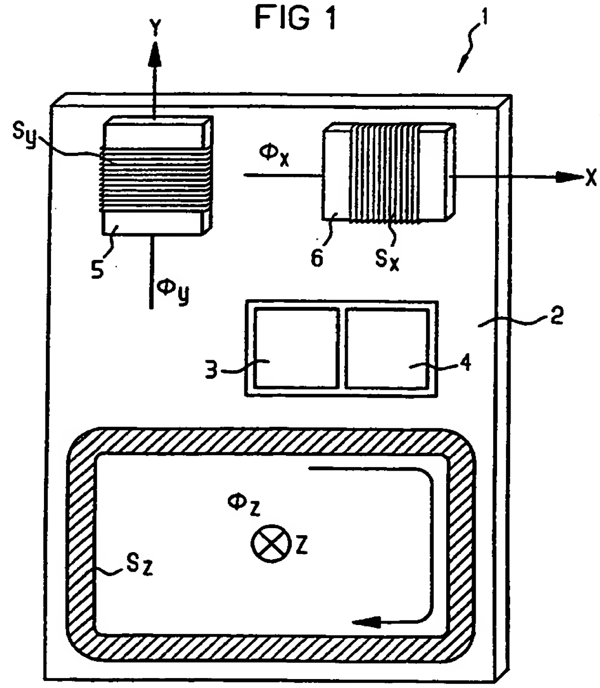

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FIG 1

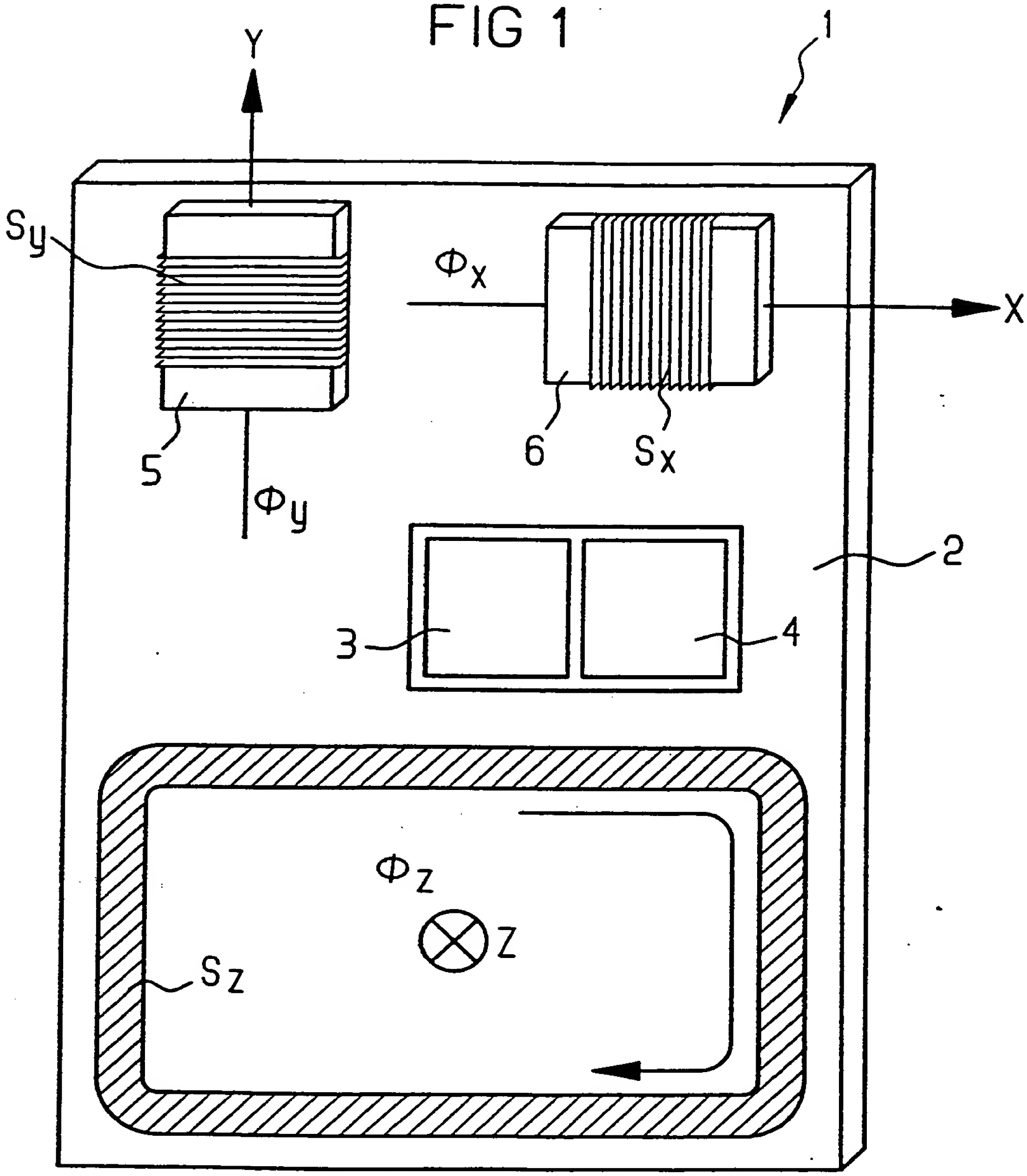

FIG 2

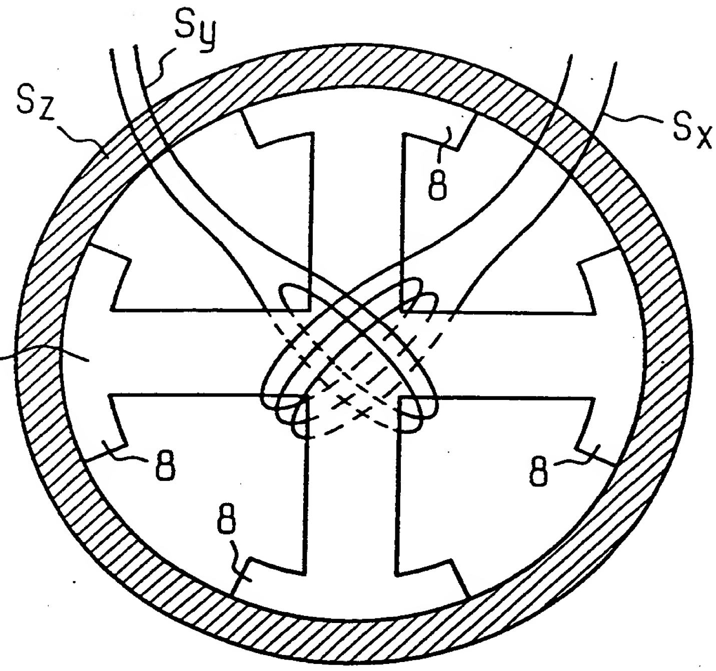

FIG 3A

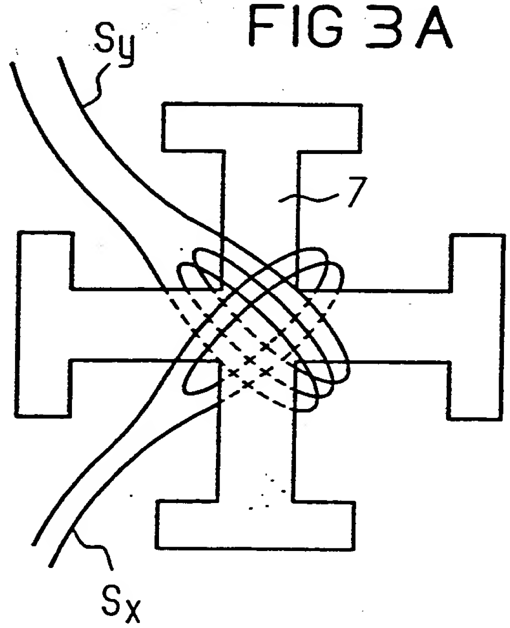

FIG 3B

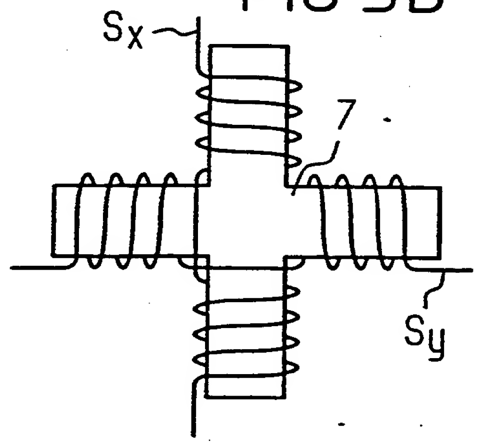

FIG 3C

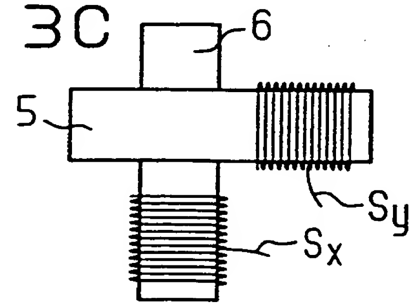

FIG 4

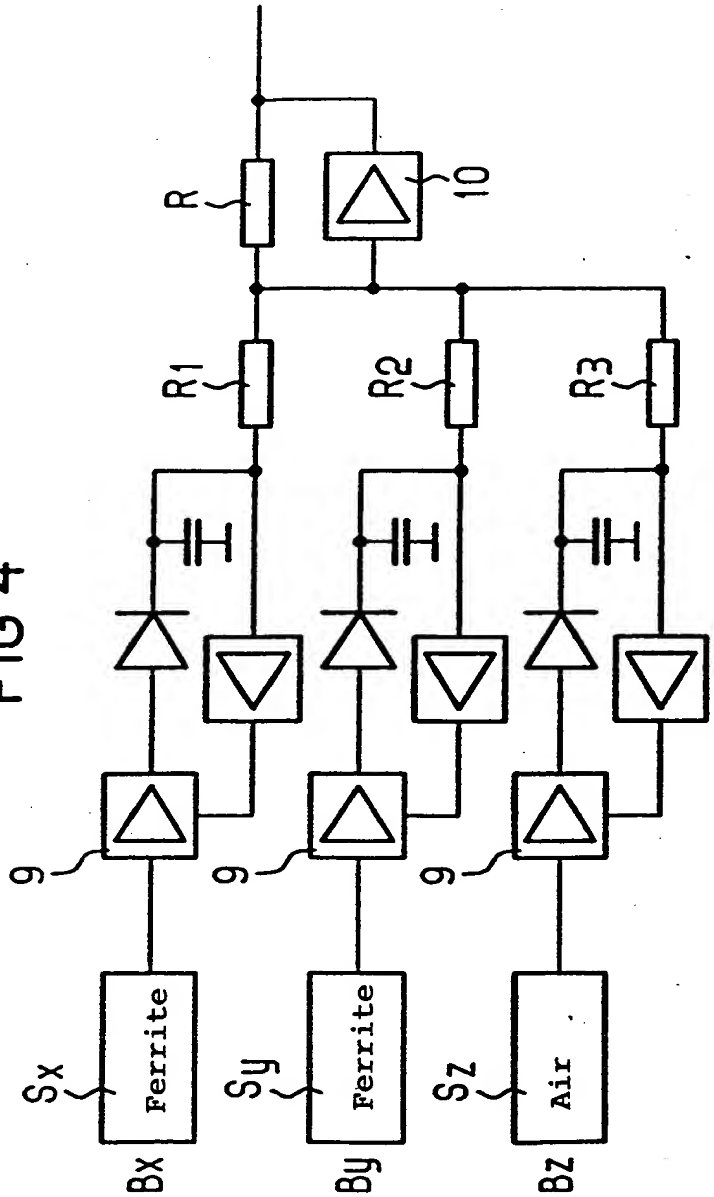

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FIG 5

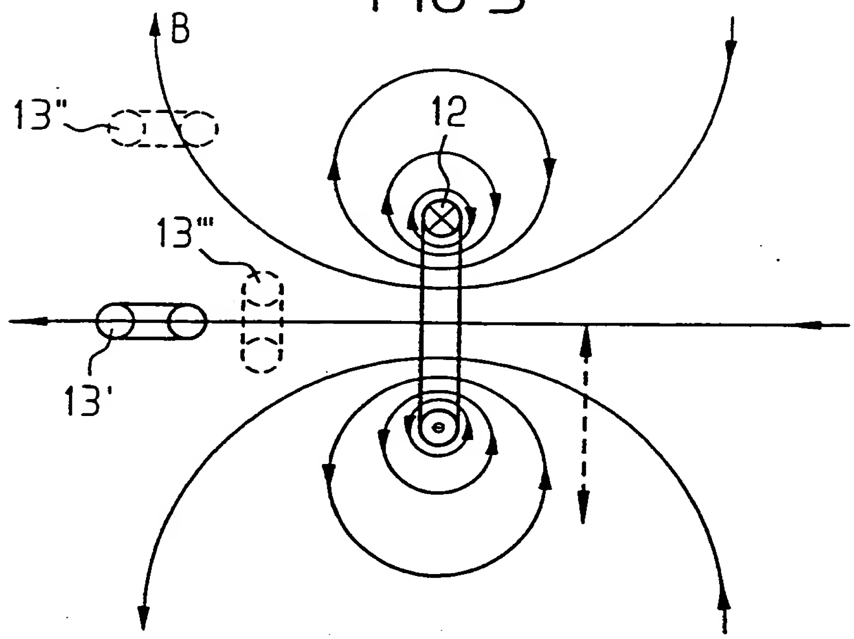


FIG 6A

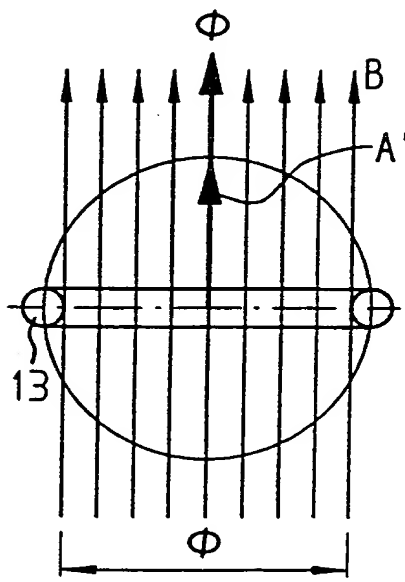


FIG 6B

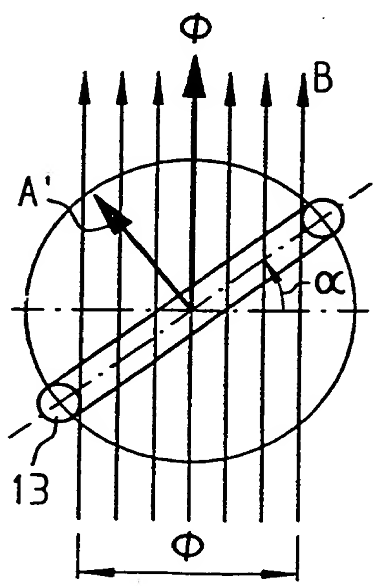
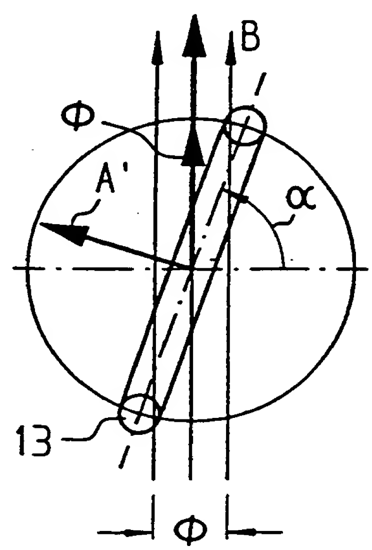


FIG 6C



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Portable signal receiver

The invention relates to a portable signal receiver, in particular for an anti-theft system of a motor vehicle.

A known signal receiver (DE 37 21 822 C1) is arranged on a chip card. It has a coil as a receiving antenna, the turns of which lie in the plane of the chip card. If such a signal receiver is used in the case of an anti-theft system for a motor vehicle, a signal transmitter is also arranged on the chip card. Signals can therefore not only be sent out to an identification unit, but can also be received from it.

If a user would like to get into his/her vehicle, an query/response dialogue is initiated first of all by actuating an initiating means. In this connection, an query signal is inductively transmitted by way of a magnetic field from a transmitting antenna in the form of a coil in the motor vehicle to a signal receiver which the user is carrying. Provided that the signal receiver receives the query signal, a response signal is generated that is sent back to the motor vehicle. There the response signal is compared with a specified signal and, if the signals correspond, a release signal is generated.

If the transmitting antenna in the vehicle and the antenna of the signal receiver are realized as coils, electromagnetic fields are generated when the coils are activated with sinusoidal signals. These fields induce a voltage in the coil of the signal receiver. In order for the induced voltage to be as large as possible, field lines must permeate the coil of the signal receiver to a sufficient extent.

In Figure 5 a magnetic field B is shown that is generated by a coil (transmitting antenna 12) located in the motor vehicle. A signal receiver with its coil

13 is moved into this magnetic field. Depending on the position and orientation (direction of the plane of the turns) of the coil 13, it is intersected to a greater or lesser extent by the magnetic field (magnetic field lines). One turn of the coil 13 thereby encloses an area which is called turn area A in the following.

The magnitude of the voltage induced in the coil 13 of the signal receiver (the flux linkage Φ is proportional thereto) is dependent *inter alia* upon an angle α (cf. Figures 6a to 6c) which is the angle between the turn area A of the coil 13 of the signal receiver (area vectors A', which are perpendicular to the turn area A, and flux linkage vectors Φ are represented in Figure 6) and the field lines of the magnetic field B generated by the transmitting antenna 12 in the motor vehicle. The area vector lies along the axis of the coil.

The voltage which is induced in the coil 13 of the signal receiver is greatest when the coil 13 is inersected perpendicularly by the magnetic field lines (Figure 6a) and is very small if the coil is arranged so as to be substantially parallel to the magnetic field lines (Figure 6c). The level of the voltage is dependent, moreover, upon the effective turn area A which is enclosed by the turns of the coil 13 of the signal receiver.

The dependence of the linkage flux Φ upon the angle is given by the generally known formula $\Phi = B*A*\cos\alpha$.

Accordingly, it may be found that no voltage or only a very small voltage is induced in the coil 13 of the signal receiver if the coil 13 is arranged so as to be parallel to the field lines (α approximately 90° implies $\cos\alpha \approx 0$) (see coil 13' in Figure 5). If the position of the coil 13 deviates from this parallel position (cf. coil 13" in Figure 5), the induced

voltage becomes greater. If, on the other hand, the coil 13 of the signal receiver is intersected perpendicularly by the magnetic field lines (α - approximately 90° -> $\cos\alpha \approx 1$), the maximum voltage is induced in the coil 1 (cf. coil 13‴ in Figure 5).

Depending on the position of the coil 13 of the signal receiver, a larger or smaller voltage is induced in the coil. In order to avoid this problem, it was proposed in an earlier German patent application (DE 195 42 441) that two frame antennae, arranged close together, are provided in a motor vehicle. The two frame antennae are then activated out of phase so that an alternating magnetic field results (cf. Figure 5, broken double arrow). The same effect would be achieved if the coil of the signal receiver were moved in a reciprocating fashion (cf. coils 13′ and 13″ in Figure 5).

In this case a very high level of outlay is required in this arrangement for the transmitting antenna in the motor vehicle, since two frame antennae close together are required which must also be out of phase in relation to each other. Moreover, the user would have to move the signal receiver to and fro so that the query signal is reliably received before getting into his/her motor vehicle.

According to the invention there is provided a portable signal receiver including three antennae each in the form of a coil, having coil axes substantially perpendicular to each other, and a receiving unit for receiving the signal from the antennae.

The invention thus provides a portable signal receiver which more reliably receives a signal from a transmitting antenna if it is arranged in the vicinity of the transmitting antenna irrespective of the angular position of the signal receiver in relation to the transmitting antenna.

The signal receiver has three antennae in the form of coils, the turn areas of which are each arranged so as to be perpendicular to each other. Provided that the signal receiver lies within the range of a transmitting antenna, as a result of the three-dimensional arrangement of the coils a voltage, which can be processed further in the signal receiver, is induced in at least one of the three coils irrespective of the angular position of the signal receiver.

The coils can be formed as air-core coils or as a ferrite coils with a ferrite core. Ferrite cores can be produced in one piece, onto which one or more coils are wound so as to be perpendicular to each other in each case.

The coils can then be arranged on a card the size of a cheque card or on a key grip of a conventional door key.

Specific embodiments of the invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a top view of a signal receiver according to the invention;

Figure 2 shows a further exemplary embodiment of a signal receiver;

Figures 3a to 3c show exemplary embodiments of ferrite cores having wound coils;

Figure 4 shows a block circuit diagram of a signal receiver;

Figure 5 shows a field line diagram of a magnetic field which is generated by a transmitting antenna in a motor vehicle; and

Figures 6a to 6c show magnetic flux linkages of a coil in the magnetic field in accordance with Figure 5.

A signal receiver 1 (Figure 1) (preferably

portable) is used for an anti-theft system of a motor vehicle. It has a carrier plate 2 and at least three receiving antennae in the form of coils S_x, S_y and S_z. The three coils S_x, S_y and S_z are electrically connected to a receiving unit 3 which can be arranged on the carrier plate 2 as an integrated semiconductor component.

When the receiver is in use in an anti-theft system, firstly an query signal is sent out with the aid of an electromagnetic field from a transmitting antenna (not shown) in, for example, the door panelling or the exterior mirrors of the motor vehicle. If the signal receiver 1 is arranged in the vicinity of the transmitting antenna, it receives the query signal by way of one or more of the coils S_x, S_y and S_z in that a voltage is induced in the coils that is dependent upon the angular position of the coils in relation to the magnetic field. Thereupon, the query signal is evaluated in the receiving unit 3.

So that a user can establish his/her authorization (authentication), a transmitting unit 4 can also be arranged on the carrier plate 2 which, after reception of the query signal, generates a response signal which contains code information specific to a user or a vehicle. Since the coils S_x, S_y and S_z can also be used as transmitting coils, the response signal is sent back to the motor vehicle by way of one or more coils S_x, S_y and S_z. It is, however, also possible for a further transmitter, for example in the form of a further coil, to be arranged on the carrier plate 2 with which the response signal is sent out.

The response signal which is received there is evaluated in a control unit. For this purpose, it is compared with an anticipated specified signal (authentication) and, if the two signals correspond at least to a large extent, a release signal is generated,

by means of which signal, for example, the doors of the motor vehicle are unlocked (access control) or a unit which is required to drive the vehicle (electronic immobilizer) in the motor vehicle is released.

Provided that the signal receiver 1 is located in the vicinity of a transmitting antenna, a query signal will be received in any case and this is not dependent upon the angular position of the signal receiver 1 in relation to the transmitting antenna or the magnetic field generated by it. The coils S_x, S_y and S_z on the signal receiver 1 are therefore directed in a "three-dimensional" manner in such a way that their turn areas (along the axes) and thus their magnetic flux vectors Φ are substantially perpendicular to each other in each case. Each coil S_x, S_y and S_z consequently has a particularly sensitive reception in a different direction in space.

The coil S_z, in the case of the first embodiment, is wound so that its turns are in the plane of the carrier plate 2 (the winding direction is indicated in this connection by means of the circumferential arrow in Figure 1) so that the magnetic flux vector Φ_z thereof is directed into the drawing plane of Figure 1 (this is to correspond to the z-axis of a system of Cartesian coordinates). The second coil S_y is wound onto a ferrite core 5 in such a way that its magnetic flux vector Φ_y points upwards in Figure 1 (this corresponds to the y-axis of the system of Cartesian coordinates). The third coil S_x is also wound onto a ferrite core 6 in such a way that its magnetic flux vector Φ_x points to the right in Figure 1 (this corresponds to the x-axis of the system of Cartesian coordinates).

The magnetic flux vectors Φ_x, Φ_y and Φ_z of the three coils S_x, S_y and S_z thus, to a substantial extent, lie on the three axes of the system of Cartesian coordinates. The turn areas of the three coils S_x, S_y

and S_z each lie so as to be perpendicular to the three axes of the system of Cartesian coordinates. Consequently, magnetic field components B_x, B_y and B_z of the spatial magnetic field generated by the transmitting antenna induce a voltage in the coil S_x, S_y and S_z which is directed in a corresponding manner in each case. The level of the respective voltage induced is of course dependent upon the angular orientation of the respective coil S_x, S_y and S_z in relation to the respective magnetic field component B_x, B_y and B_z and the magnitude of the latter (cf. also Figures 6a to 6c).

The coils S_x, S_y and S_z can then be arranged on the carrier plate 2 so as to be distributed and spatially separate from each other. It is also possible for the coils S_x, S_y and S_z to be wound so as to be as close together as possible, yet with turn areas which are substantially perpendicular to each other. This is shown in the case of the exemplary embodiment in accordance with Figure 2. In this connection, the coils S_x and S_y are wound onto a ferrite core 7 which is formed in the shape of a cross with pole shoes 8 at the ends of its limbs. The coils S_x and S_y are each wound diagonally in relation to the limbs of the ferrite core 7 and thus perpendicularly in relation to each other (in each case perpendicularly in relation to the drawing plane). The coil S_z is wound in a substantially annular manner onto the pole shoes 8 of the ferrite core 7. Its turn area A is then parallel to the drawing plane. Thus the turn areas of the three coils S_x, S_y and S_z are each arranged so as to be substantially perpendicular to each other.

The embodiment of the signal receiver 1 in accordance with Figure 2 has very small dimensions, especially thickness. The coils S_x, S_y and S_z in this case are arranged in a very confined space. It is

therefore easy to install such a signal receiver 1 in housings which have small dimensions. In particular, the coils can be made thin in one direction so that the signal receiver including the coils 5, 6, 7 mounted on the carrier plate 2 can be substantially flat.

The coil S_z in Figure 1 is formed as an air-core coil and in Figure 2 is formed, in part, as a ferrite coil. In the case of an air-core coil, the interior of the coil is not filled with a magnetically conductive material; the coil could be filled with air or plastics.

The coil S_z is applied directly to the carrier plate 2. It can, for example, be made of wires which are secured in a coil-shaped manner to the carrier plate 2, for example in grooves. The carrier plate 2 can also be formed as a printed circuit board and the turns of the coil S_z can be in the form of printed conductors. The carrier plate can be provided with ferrite material in the region of the turn area of the coil S_z, thereby increasing its quality/coupling factor.

The coils S_x and S_y are formed as ferrite coils in Figures 1 and 2, in which case the turns are wound onto a ferrite core 5, 6, 7. The interior of the coils S_x and S_y is then therefore to a large extent filled with a material which has a very high level of relative permeability μ_r. It is known that the magnetic flux Φ is intensified by means of a ferrite core. Consequently, whilst producing the same effect it is possible to reduce the diameter of the turns (and thus the turn area) of the coils S_x, S_y and S_z, if the coils are wound onto a ferrite core.

Further exemplary embodiments of the coils S_x and S_y and the ferrite cores 5, 6 or 7 thereof are shown in Figures 3a to 3c. The ferrite cores 5, 6 or 7 can be formed in one piece in a substantially cross-shaped manner. Each coil S_x and S_y can, however, also have its

own ferrite core 5, 6 which then in each case is arranged in a substantially perpendicular manner in relation to the ferrite core of the other coil - in part lying one on top of the other as in Figure 3c.

If the coil S_z is formed so as to be particularly large (that is, with a high coupling factor or a high Q, for example as an air-core coil having a large turn diameter or as a large ferrite coil having a ferrite material that has a high level of permeability), this has the advantage that when the electromagnetic field is received energy can also be received. If no energy store is arranged on the carrier plate 2 or if this energy store is empty, the received energy alone can suffice in order to evaluate the query signal and, if applicable, generate and also send out the response signal. Such a special coil is therefore used to realize an emergency running function in the event of battery failure.

The energy can also be received by way of a separate coil which is not shown. If this coil is designed to have a particularly high coupling factor and/or high Q, the energy transmission is particularly effective.

The three coils S_x, S_y and S_z are all connected to the receiving unit 3 and to the transmitting unit 4 (Figure 4). The voltage generated in each coil S_x, S_y and S_z is independently amplified in a corresponding amplifier 9 and fed to a common adder 10. The induced voltages of the spatial magnetic field components B_x, B_y and B_z output by the amplifiers are added in the adder 10.

Instead of the adder 10 it is also possible to provide a maximum detector - not shown - which only conducts the largest voltage, induced in the coils S_x, S_y and S_z, onwards for the purposes of evaluation. Thus undesirable, comparatively small magnetic fields are

suppressed for evaluation purposes (overreach avoidance).

If too small a voltage is induced in one or two of the three coils S_x, S_y and S_z, there still remains the third coil in which a comparatively large voltage is induced on the basis of the spatial magnetic field and the three-dimensional arrangement of the coils S_x, S_y and S_z, provided that the signal receiver 1 is located in the vicinity of the transmitting antenna and thus within the magnetic field.

The coils S_x, S_y and S_z are formed with such small dimensions (especially thickness) that the carrier plate 2, together with the coils S_x, S_y and S_z, corresponds to a small flat card in the form of a cheque card or credit card (also called a smart card). Such cards have a standard form. The thickness of the coils is preferably less than 5mm, or further preferably less than 2mm or even 1mm, so that the whole signal receiver can be adequately thin. The carrier plate 2 can also be formed to be sufficiently small that, together with the coils S_x, S_y and S_z, it can be secured on a key grip of a mechanical door/ignition key. The user can therefore carry the signal receiver 1 about his/her person in comfort.

The signal receiver 1 can also be arranged in other, functionally equivalent housings. The shape of the housing is of no consequence for the invention, as long as the coils S_x, S_y and S_z can be arranged in the manner according to the invention, i.e. so as to be substantially perpendicular to each other and with (very) small dimensions.

Since the three coils S_x, S_y and S_z are directed in (substantially) all three directions in space x, y and z, the angular position of the signal receiver 1 in relation to the transmitting antenna is of no importance. The user can therefore carry his/her

signal receiver 1 with him/her in one of his/her pockets or in a hand bag. The signal receiver 1 can also be deposited in a compartment in the vehicle. As long as the signal receiver 1 is located within the range of the transmitting antenna and the transmitting antenna generates a sufficiently large magnetic field, the query signal is reliably received by means of the signal receiver 1 according to the invention.

If a transmitting unit 4 is also provided in addition, the transmitting unit 4 can send back a response signal after the query signal has been received. Thus authentication is carried out. If the authentication is successful, that is, if the response signal turns out to be authorized, door locks can be locked or unlocked or an immobilizer in the motor vehicle can be cancelled.

It is not only possible to use the signal receiver 1 for anti-theft systems for motor vehicles. It can be used whenever a signal is inductively sent out from a transmitting antenna by way of a magnetic field and is to be received by the portable signal receiver 1. Binary information, which is to be transmitted, is then transmitted in a modulated manner with the aid of the magnetic field. When the signal is received, the binary information is demodulated and evaluated.

The range of inductively transmitted signals is approximately 1 to 2 m. The range is dependent upon the transmitting frequency which, for applications in the field of automotive engineering, is preferably 125 kHz. The range is also dependent upon the transmitting power and the directional characteristics of the transmitting antenna. The response signal is sent back to the motor vehicle, with a transmitting frequency of 433 MHz for example. Here the range can be substantially greater.

The ferrites used can consist of pure magnetic

materials (compounds of iron (oxides) and manganese oxides, nickel oxides or zinc oxides) or even of a plastics material into which ferromagnetic particles are introduced (plastoferrites). Ferrite cores consist of ferrites and can be produced as stamped portions and so as to be very thin. The thickness of a coil wound onto a ferrite core can consequently lie in the range of 1 to 2 mm. The length of the limbs of the ferrites can lie in the cm-range. Small structural forms can therefore be realized that only occupy a small amount of space on the carrier plate 2.

If the signal receiver 1 is arranged on a smart card, it can advantageously be carried in the user's shirt or trouser pocket. It can also easily be carried about in a hand bag or similar.

Depending on the preferred direction in which the magnetic field generated by the transmitting antenna is directed, and on a preferred angular position of the signal receiver 1, that coil S_x, S_y and S_z which is mainly permeated by the magnetic field in this preferred direction can be formed in a particularly characteristic manner. The turns of this coil S_x, S_y or S_z can then have a comparatively large turn diameter (comparatively large turn area). The permeability can also be increased by a highly permeable ferrite core. The number of turns of the coil S_x, S_y or S_z can likewise be raised. As a result of this additional outlay it is then more likely that a signal will be received with sufficient strength by the signal receiver 1, if the signal receiver 1 is located within the range of the transmitting antenna and the latter also sends out a signal.

It suffices if the signal receiver 1 can receive signals. For use in an anti-theft system of a motor vehicle it is advantageous if in addition a transmitting unit 4 is also provided that sends back a

response signal after the query signal has been received. Since the coils S_x, S_y and S_z can not only receive signals, but also transit them, the signal receiver 1 together with the transmitting unit 4 can act as a transponder which initiates the generation of a response signal as a result of the reception of the query signal.

Claims

1. A portable signal receiver including

three antennae each in the form of a coil, having coil axes substantially perpendicular to each other, and

a receiving unit for receiving the signal from the antennae.

2. A signal receiver according to claim 1, in which the coils are air-core coils or ferrite coils.

3. A signal receiver according to claim 2, in which a ferrite core is arranged in the interior of each of the coils.

4. A signal receiver according to claim 2 or 3, in which a single ferrite core is provided substantially in the shape of a cross having two limbs, around which two of the coils are wound so as to be perpendicular to each other.

5. A signal receiver according to any preceding claim, wherein the coils and the receiving unit are arranged on a carrier plate.

6. A signal receiver according to claim 5, in which the carrier plate is substantially in the form of a cheque card.

7. A signal receiver according to claim 6, in which the coils have a thickness of no more than 5mm in the direction perpendicular to the carrier plate so that the signal receiver is substantially in the form of a cheque card.

8. A signal receiver according to claim 5, in which the carrier plate is arranged on a key grip.

9. A signal receiver according to any preceding claim, having a transmitting unit for transmitting a response to a received signal.

10. A portable signal receiver substantially as herein described with reference to and as shown in Figure 1,

Figure 2, Figure 3A, Figure 3B, or Figure 3C of the accompanying drawings.

11. An anti-theft system for a motor vehicle having a portable signal receiver according to any preceding claim.

The Patent Office

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Application No:	GB 9809323.0	**Examiner:**	Gareth Lewis
Claims searched:	1-3, 5-7, 9	**Date of search:**	27 October 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H1Q (QAX, QBH, QBX) H4D (DFBB, DFBC)

Int Cl (Ed.6): H01Q 1/36 7/06 7/08 9/27 11/08 21/28 25/00 G01S 3/18 3/30

Other: Online : WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2180724 A	ICI Australia Ltd (abstract)	1
X, P	EP 0783190 A1	Texas Instruments (Figs 1 and 2, abstract, col. 4 lines 1-14)	1,2,9
X	EP 0762535 A1	Mitsubishi Materials Corp. (Figs 4A, 4B, 5A and 5B, page 3 lines 49-58, page 4 line 14-15 and page 5 lines 1-6)	1,2,5,6, 7,9
X	EP 0733916 A2	Silvretta-sherpas Sportartikel GmbH (Fig. 3, abstract and claims 1 and 7)	1,2,3
X	EP 0058412 A2	Honeywell Inc. (Fig. 3, page 11 line 26 to page 12 line 3	1,2,3
X	WO 97/07414 A1	Tetra Laval holdings & finance SA (fig 1A and 1B and abstract)	1,9
X	US 5281941	Bernstein (Fig. 3, col. 1 lines 7-10, col. 1 line 64 to col. 2 line 3)	1
X	US 4642786	Position Orientation Systems Ltd. (Fig. 3 and 5, col. 20 lines 10-15 and col. 21 lines 7-17)	1,2

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office

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Application No:	GB 9809323.0	**Examiner:**	Gareth Lewis
Claims searched:	all	**Date of search:**	23 October 1998

Category	Identity of document and relevant passage	Relevant to claims

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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&	Member of the same patent family		